Relationship between electron density height profile and convection flow speed in the polar cap patches and blobs

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We focus on the enhanced electron density in the ionospheric F region associated with polar patches and blobs using the data taken with European Incoherent Scatter (EISCAT) radar and all-sky imager at Longyearbyen. Polar patches are regions of high-density plasma in the polar cap F-region. They are thought to be generated by expansion of the polar cap convection driven by pulsed reconnection [*Lockwood and Carlson*, 1992] and transported anti-sunward by $\boldsymbol{E}\times\boldsymbol{B}$ drift. Subsequently they exit polar cap and evolve into blobs in the sunward return flow region of closed field line. These phenomena play important role on electron density fluctuations in the polar cap and high-latitude ionosphere. However detailed processes controlling the electron density distribution are not understood well. EISCAT Svalvard Radar (ESR) observed the enhanced electron density in the F-region associated with polar patches 1730 to 2230 UT (2000-0100 MLT) on 11 January 2016. We interpreted that it is not caused by auroral electron precipitation because there is no enhanced electron density in the E-region and no enhanced ion temperature in the F-region. The direction of IMF was southward during 1530-1640 UT, 1730-1820 UT and 1930-2350 UT. Compared with the simultaneous OI (630.0 nm) emission all-sky images, eleven polar patches were identified. We find that the electron density profiles in the polar patches were classified into the two groups as follows: One is that electron density was enhanced in the altitude range from 300 to 500 km. The other is that the enhancement in electron density ranged from 250 to 350 km altitudes. On the other hand, SuparDARN data showed that the ion velocity in the polar cap in the latter case were higher than that in the former case. Thus, we suggest that this difference would be caused by the difference of ion convection speed in the polar cap as described in the following mechanism. When the ion velocity is high, the difference between the ion and neutral velocity becomes large and then the ion temperature increases by frictional heating. The increased ion temperature contributes to the growth of rate coefficients of $O^+ + N_2 \rightarrow NO^+ + O$ and $O^+ + O_2 \rightarrow O_2^+ + O$ reactions [*Schunk et al.*, 1976]. Consequently, electron density decreases by $NO^+ + e \rightarrow N + O$ and $O_2^+ + e \rightarrow O + O$ reactions. At high altitudes, NO^+ and O_2^+ density due to the enhanced NO^+ and O_2^+ scale heights with the increased ion temperature.
Additionally, the successive electron density enhancements in the F region were observed by EISCAT Tromsø UHF Radar from 2037 to 2100 UT (2200 to 2230 MLT) on the same day. Simultaneous GPS-TEC map data indicates that it was probably caused by blobs in the closed field region originated from the polar cap. This interval was in the recovery phase of substorm according to AE index. Since the polar cap boundary shrinks in the substorm recovery phase, we suggest that Tromsø located into the sunward return flow region in the dusk convection cell, and then blobs passed over Tromsø.

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